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(54) **MONITORING AND LOCATING FUSE CUTOUTS**

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G01R 31/08	(2020.01)
H02H 7/04	(2006.01)
H02H 1/00	(2006.01)
H02H 3/04	(2006.01)
H01H 71/08	(2006.01)

(52) **U.S. Cl.**

CPC ***H01H 85/0241*** (2013.01); ***G01R 31/085*** (2013.01); ***H02H 1/0061*** (2013.01); ***H02H 3/046*** (2013.01); ***H02H 7/04*** (2013.01); *H01H 2071/088* (2013.01)

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CPC G01R 31/085; G01R 31/086; H01H 2071/088; H01H 85/30; H01H 85/0241; H02H 1/0061; H02H 3/046; H02H 7/04

See application file for complete search history.

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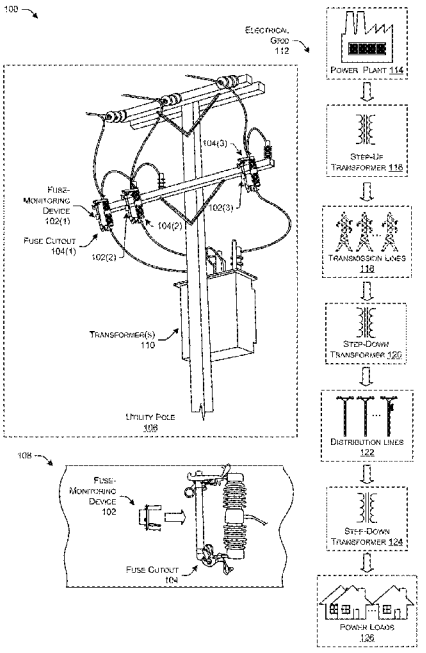
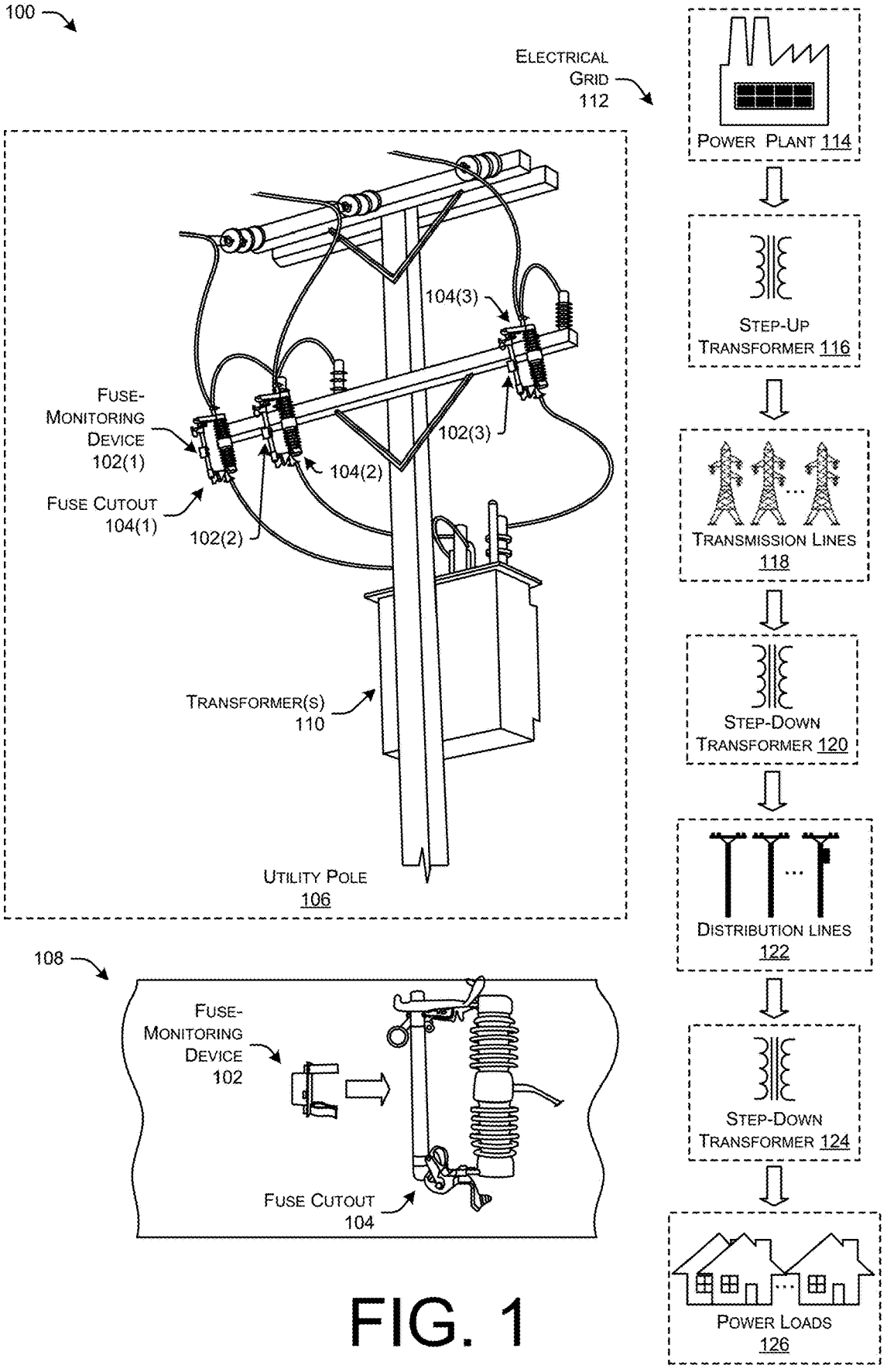
(57) **ABSTRACT**

This disclosure describes techniques implemented at least in part by a fuse-monitoring device to detect when a fuse cutout in an electric power system opens to disconnect a device and/or a load from a power line, and provides an indication of a location of the opened fuse cutout to a utility provider. The fuse-monitoring device may be attached to a fuse holder of the fuse cutout, and may include a movement sensor that detects when the fuse holder swings open due to its fuse melting, or blowing. The fuse-monitoring device may send a notification to the utility provider indicating that the fuse holder has swung open. The fuse-monitoring device may include a GPS sensor to determine the location of the fuse cutout, and may also notify the utility provider of the location of the fuse cutout so a line crew can quickly locate the fuse cutout that requires maintenance.

22 Claims, 7 Drawing Sheets

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POWER PLANT 114
STEP-UP TRANSFORMER 116
TRANSMISSION LINES 118
STEP-DOWN TRANSFORMER 120
DISTRIBUTION LINES 122
STEP-DOWN TRANSFORMER 124
POWER LOADS 126
104(3)
FUSE-MONITORING DEVICE 102(1)
102(3)
104(2)
FUSE CUTOUT 104(1)
102(2)
TRANSFORMER(S) 110
UTILITY POLE 106
108
FUSE-MONITORING DEVICE 102
FUSE CUTOUT 104

FIG. 1

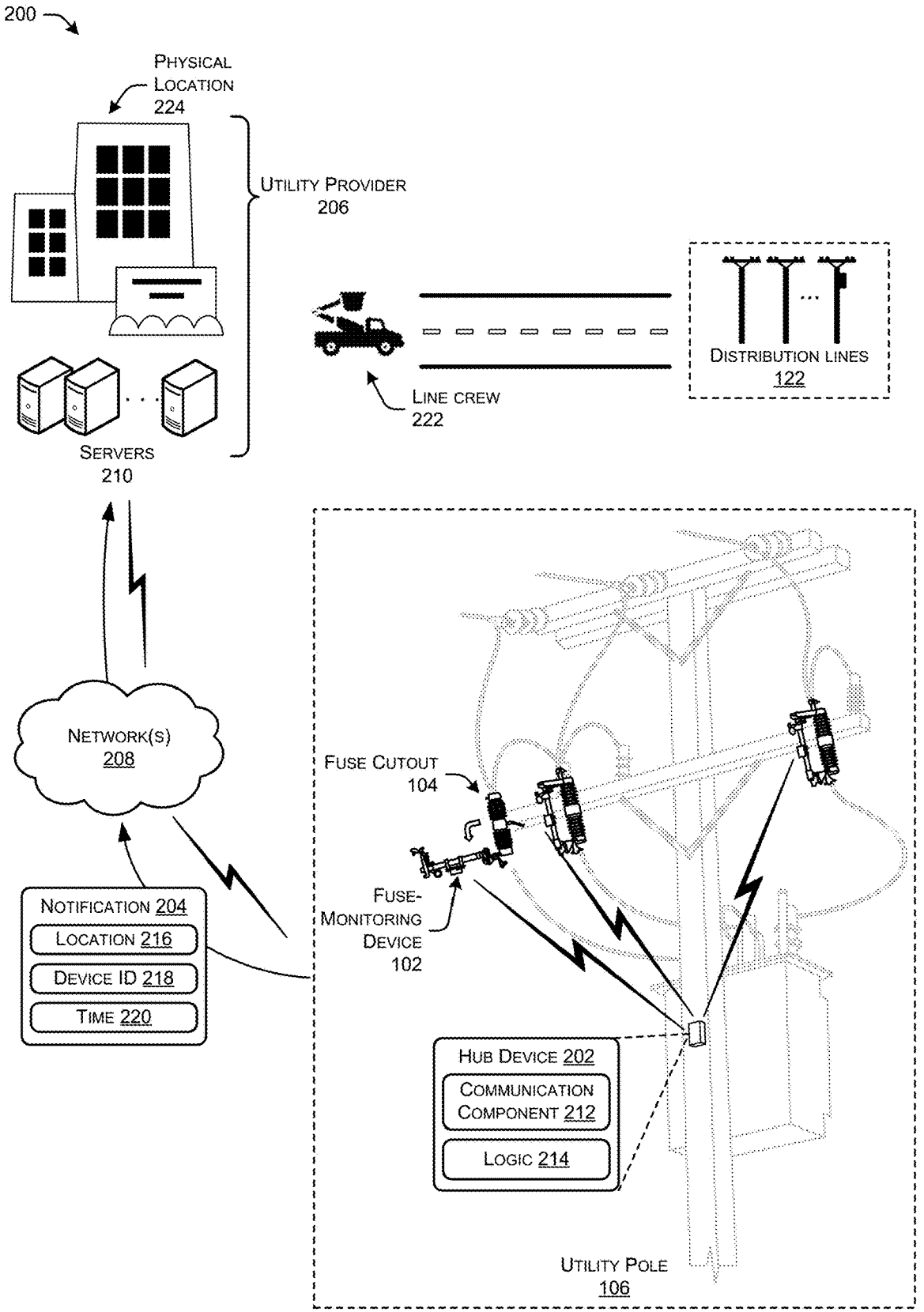
200
PHYSICAL LOCATION 224
UTILITY PROVIDER 206
SERVERS 210
LINE CREW 222
DISTRIBUTION LINES 122
NETWORK(S) 208
NOTIFICATION 204
LOCATION 216
DEVICE ID 218
TIME 220
FUSE CUTOUT 104
FUSE-MONITORING DEVICE 102
HUB DEVICE 202
COMMUNICATION COMPONENT 212
LOGIC 214
UTILITY POLE 106

FIG. 2

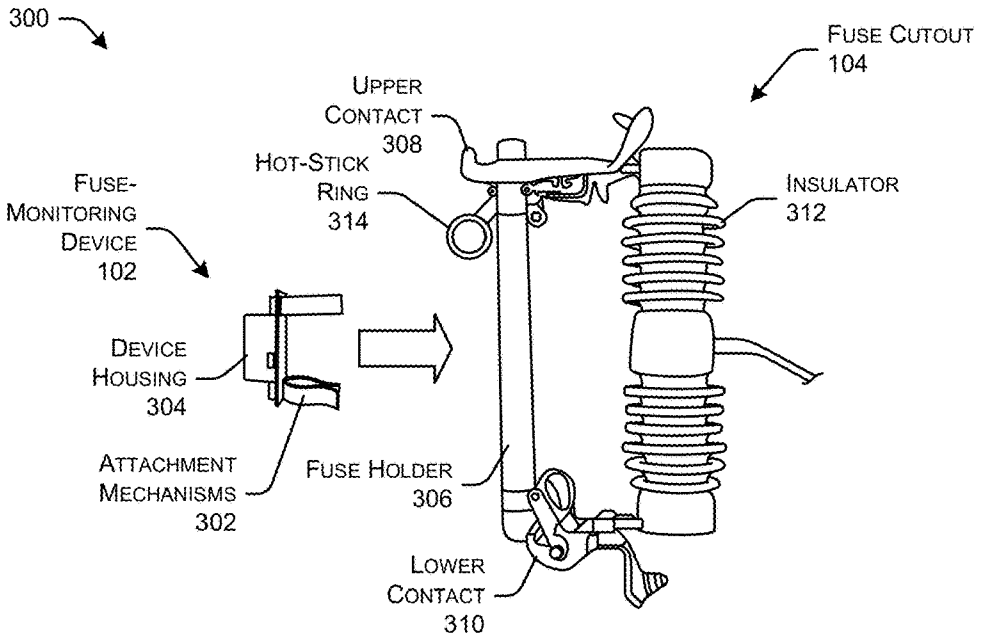
300
FUSE CUTOUT
104
UPPER
CONTACT
308
HOT-STICK
RING
314
INSULATOR
312
FUSE-
MONITORING
DEVICE
102
DEVICE
HOUSING
304
ATTACHMENT
MECHANISMS
302
FUSE HOLDER
306
LOWER
CONTACT
310

FIG. 3A

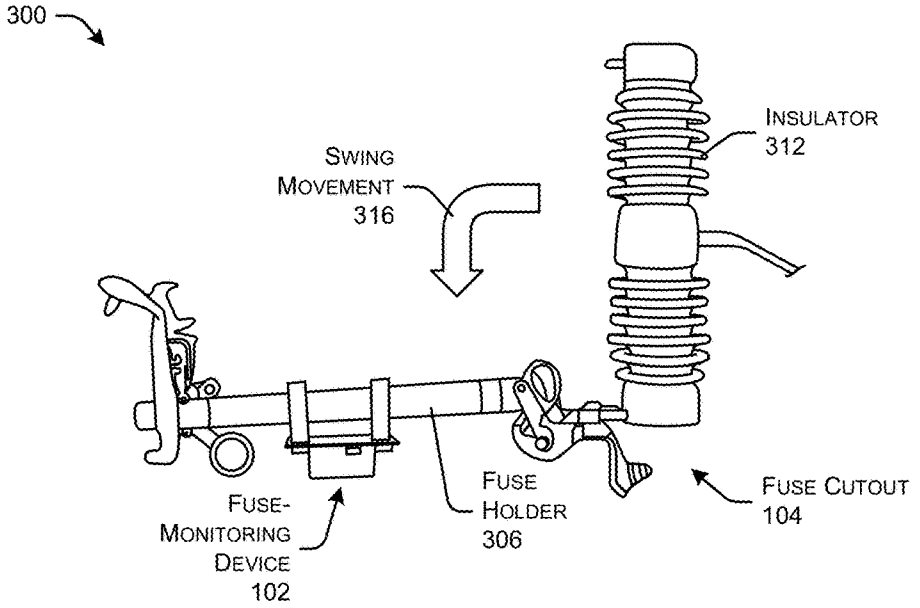
300
INSULATOR
312
SWING
MOVEMENT
316
FUSE
HOLDER
306
FUSE CUTOUT
104
FUSE-
MONITORING
DEVICE
102

FIG. 3B

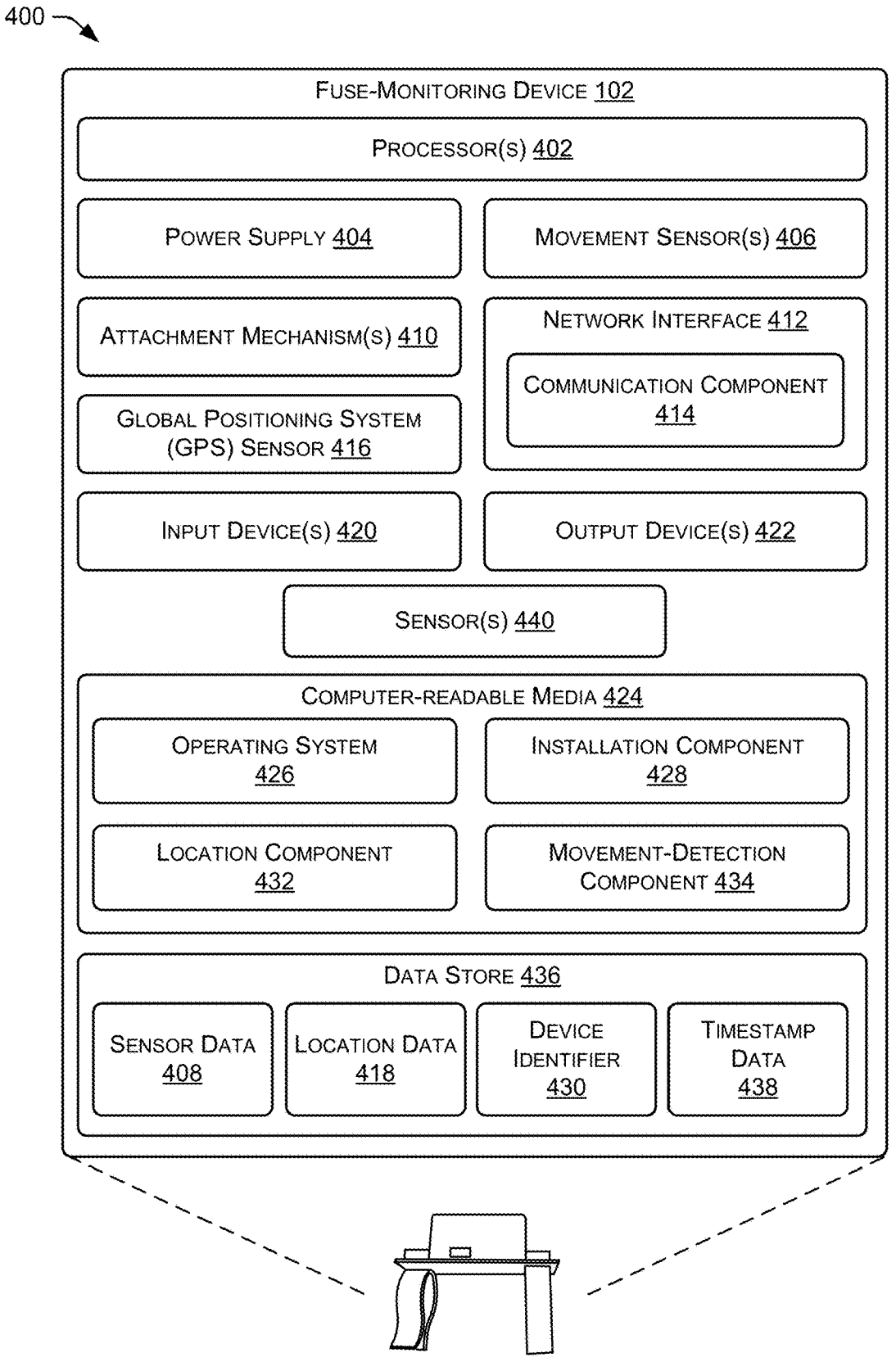
400
FUSE-MONITORING DEVICE 102
PROCESSOR(S) 402
POWER SUPPLY 404
MOVEMENT SENSOR(S) 406
ATTACHMENT MECHANISM(S) 410
NETWORK INTERFACE 412
COMMUNICATION COMPONENT 414
GLOBAL POSITIONING SYSTEM (GPS) SENSOR 416
INPUT DEVICE(S) 420
OUTPUT DEVICE(S) 422
SENSOR(S) 440
COMPUTER-READABLE MEDIA 424
OPERATING SYSTEM 426
INSTALLATION COMPONENT 428
LOCATION COMPONENT 432
MOVEMENT-DETECTION COMPONENT 434
DATA STORE 436
SENSOR DATA 408
LOCATION DATA 418
DEVICE IDENTIFIER 430
TIMESTAMP DATA 438

FIG. 4

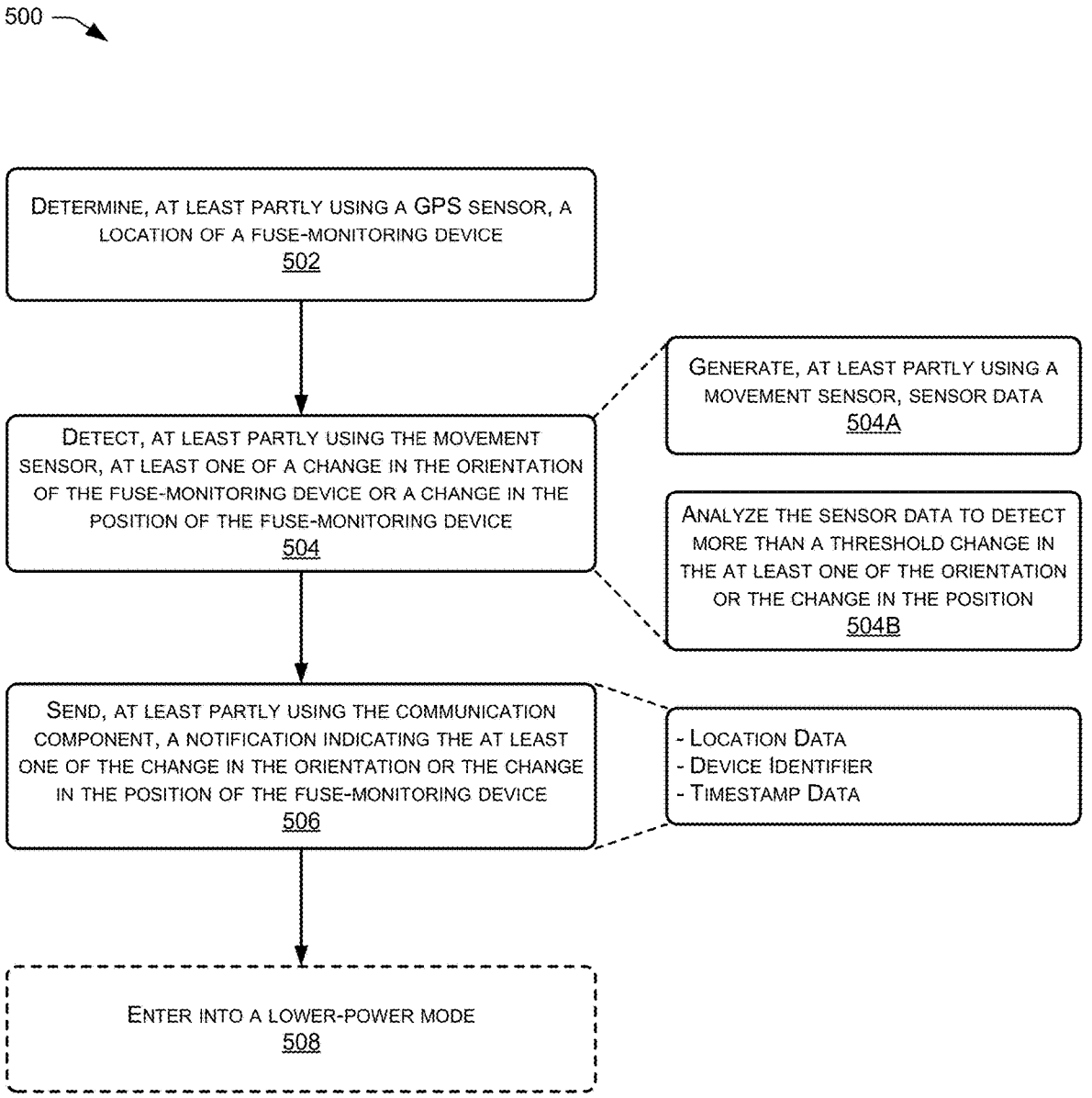
500
DETERMINE, AT LEAST PARTLY USING A GPS SENSOR, A LOCATION OF A FUSE-MONITORING DEVICE
502
DETECT, AT LEAST PARTLY USING THE MOVEMENT SENSOR, AT LEAST ONE OF A CHANGE IN THE ORIENTATION OF THE FUSE-MONITORING DEVICE OR A CHANGE IN THE POSITION OF THE FUSE-MONITORING DEVICE
504
GENERATE, AT LEAST PARTLY USING A MOVEMENT SENSOR, SENSOR DATA
504A
ANALYZE THE SENSOR DATA TO DETECT MORE THAN A THRESHOLD CHANGE IN THE AT LEAST ONE OF THE ORIENTATION OR THE CHANGE IN THE POSITION
504B
SEND, AT LEAST PARTLY USING THE COMMUNICATION COMPONENT, A NOTIFICATION INDICATING THE AT LEAST ONE OF THE CHANGE IN THE ORIENTATION OR THE CHANGE IN THE POSITION OF THE FUSE-MONITORING DEVICE
506
- LOCATION DATA
- DEVICE IDENTIFIER
- TIMESTAMP DATA
ENTER INTO A LOWER-POWER MODE
508

FIG. 5

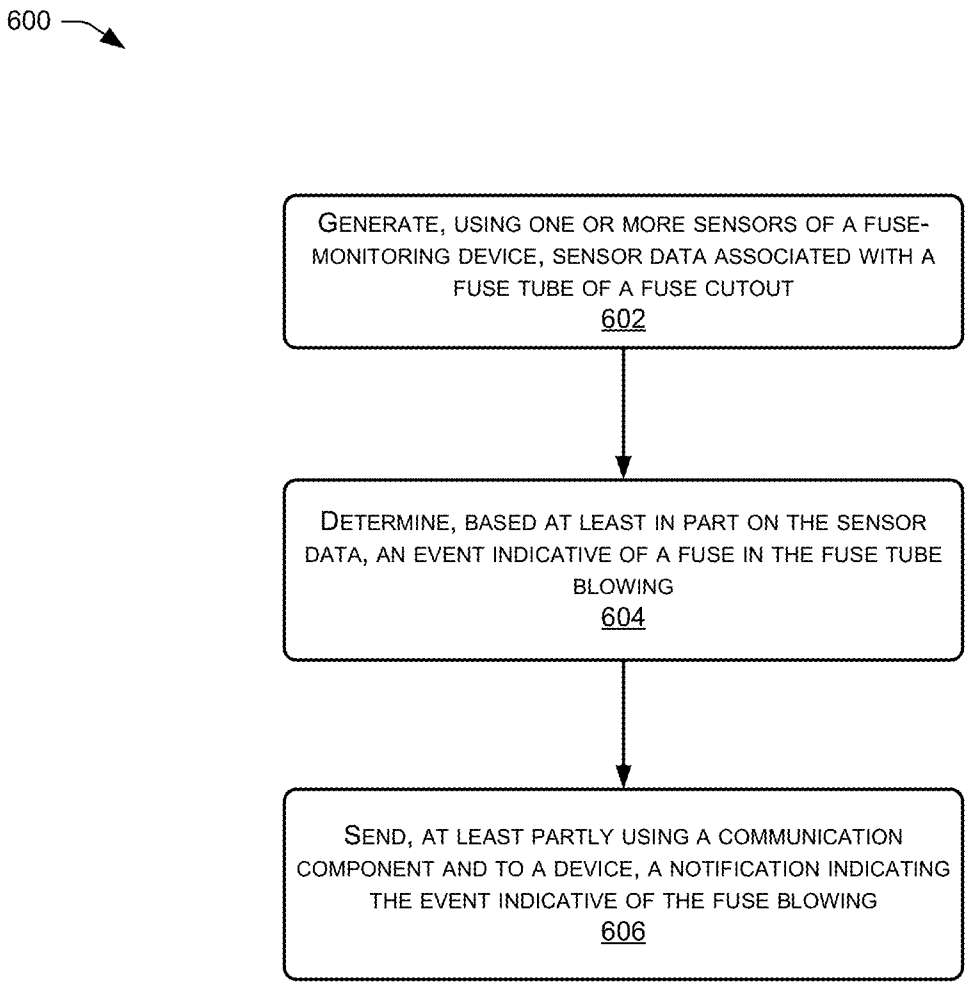
600
GENERATE, USING ONE OR MORE SENSORS OF A FUSE-MONITORING DEVICE, SENSOR DATA ASSOCIATED WITH A FUSE TUBE OF A FUSE CUTOUT
602
DETERMINE, BASED AT LEAST IN PART ON THE SENSOR DATA, AN EVENT INDICATIVE OF A FUSE IN THE FUSE TUBE BLOWING
604
SEND, AT LEAST PARTLY USING A COMMUNICATION COMPONENT AND TO A DEVICE, A NOTIFICATION INDICATING THE EVENT INDICATIVE OF THE FUSE BLOWING
606

FIG. 6

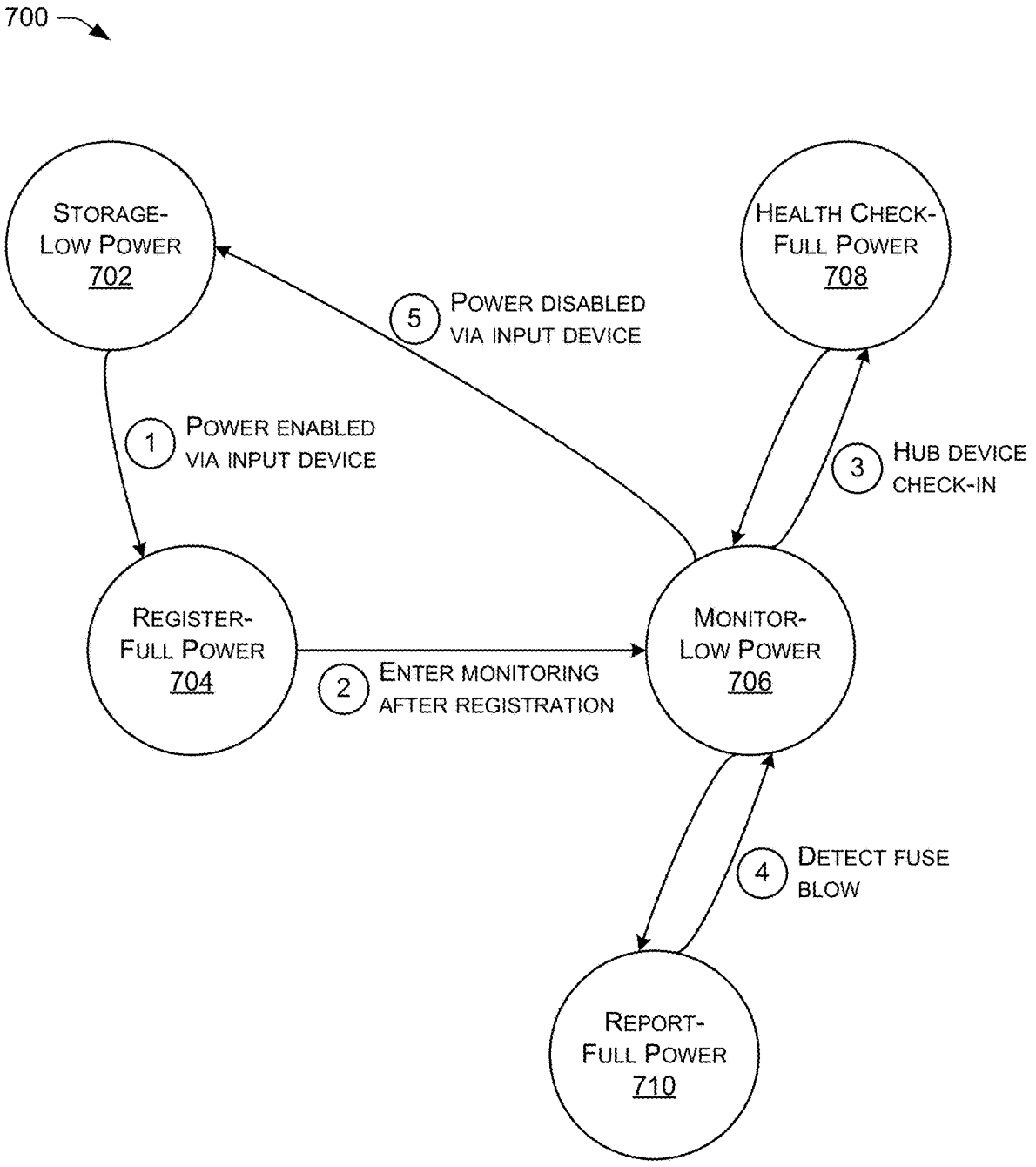
700
STORAGE-
LOW POWER
702
HEALTH CHECK-
FULL POWER
708
5
POWER DISABLED
VIA INPUT DEVICE
1
POWER ENABLED
VIA INPUT DEVICE
3
HUB DEVICE
CHECK-IN
REGISTER-
FULL POWER
704
2
ENTER MONITORING
AFTER REGISTRATION
MONITOR-
LOW POWER
706
4
DETECT FUSE
BLOW
REPORT-
FULL POWER
710

FIG. 7

MONITORING AND LOCATING FUSE CUTOUTS

BACKGROUND

In electric power distribution, fuse cutouts are utilized on power lines to protect devices and loads from overcurrent due to current surges or other current overloads. In a distribution line example, an overcurrent caused by a fault in a transformer may result in a fuse of a fuse cutout to melt, which results in a fuse holder (or fuse body) of the cutout to swing open and disconnect the transformer from a power line. While these fuse cutouts are essential power-protection devices to protect devices and loads from overcurrent, once a fuse of a fuse cutout is blown, the fuse must be manually replaced by line crews. Although the act of manually replacing the blown fuse is relatively simple, the process of tracing the location of the fuse cutout with the blown fuse in the power grid can be time and/or resource intensive.

Utility providers utilize various techniques to help narrow down a location of a fuse cutout that has a blown fuse, such as through phone calls or other communications from customers who have lost power. Additionally, utility providers may utilize fault indicators that detect changes in magnetic fields caused by overcurrent flows through the fuses, and provide localized, visual indications (e.g., blinking lights) to line crews indicating which fuse cutout needs maintenance. However, line crews still experience difficulties narrowing down the location of fuse cutouts that utilize fault indicators in order to see the visual indication of which fuse cutout requires maintenance. Accordingly, utility providers often suffer from time and resource inefficiencies when locating fuse cutouts that have blown fuses which require maintenance from line crews.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description is set forth below with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The use of the same reference numbers in different figures indicates similar or identical items. The systems depicted in the accompanying figures are not to scale and components within the figures may be depicted not to scale with each other.

FIG. **1** illustrates an example environment where fuse-monitoring devices are attached to fuse cutouts for a three-phase power line on a utility pole in an electric power grid. The illustrated fuse-monitoring devices are installed to monitor the fuse cutouts in order to help a utility provider, or other entity, determine a location of a fuse cutout with a blown fuse.

FIG. **2** illustrates an example environment where at least one fuse-monitoring device determines that a fuse of a fuse cutoff has blown. The fuse-monitoring device, and/or a hub device, may send a notification to a utility provider that indicates the location of the fuse cutout with the blown fuse.

FIG. **3**A illustrates an example fuse-monitoring device being detachably coupled to an example fuse cutout.

FIG. **3**B illustrates an example fuse-monitoring device attached to an example fuse cutout to detect a swing movement of a fuse holder of the fuse cutout.

FIG. **4** illustrates component diagram of an example fuse-monitoring device configured to determine that a fuse cutout has blown a fuse, and notify a utility provider of a location of the fuse cutout.

FIG. **5** illustrates a flow diagram of an example process for detecting movement of a fuse-monitoring device that indicates that a fuse of a fuse cutout has blown.

FIG. **6** illustrates a flow diagram of an example process for using sensor data generated by one or more sensors of a fuse-monitoring device to determine that a fuse of a fuse cutout has blown.

FIG. **7** illustrates a state diagram indicating example power states that a fuse-monitoring device progresses through.

DETAILED DESCRIPTION

This disclosure describes techniques implemented at least in part by a fuse-monitoring device that detects when a fuse cutout in an electric power system disconnects a device and/or a load from a power line, and provides an indication of a location of the disconnected fuse cutout to a service provider, such as a utility provider. In some examples, the fuse-monitoring device described herein is detachably coupled to a fuse holder (also referred to herein as a "fuse tube") that houses a fuse of the fuse cutout such that, when the fuse melts or "blows" and causes the fuse holder to swing open, a movement sensor housed in the fuse-monitoring device may detect the swinging of the fuse holder. The fuse-monitoring device may also include a global positioning system (GPS) sensor to determine a location of the fuse-monitoring device, and upon detecting the movement caused by the swinging of the fuse holder, transmit a notification to the service provider indicating the location of the opened fuse cutout. Further, the fuse-monitoring device may notify the service provider of the time when the fuse cutout opened, and also a device identifier for the fuse-monitoring device. In this way, utility providers or other service providers may in real-time or near-real-time identify more precise locations of fuse cutouts that opened, and dispatch line crews to replace the fuse and/or remedy the condition that caused the overcurrent. Accordingly, the fuse-monitoring devices described herein leverage the use of relatively simple movement sensors and GPS sensors to efficiently monitor and locate fuse cutouts that require maintenance, thereby conserving time and resources.

In some examples, the fuse-monitoring device described herein may include one or more fuse-attachment mechanisms, such as snap-fit or press-fit clips, that allow line crews to easily attach, and detach, the fuse-monitoring device from a fuse holder of a fuse cutout. Further, the fuse-attachment mechanism may be interchangeable such that differently sized fuse-attachment mechanisms may be added and removed from the fuse-monitoring device to enable the fuse-monitoring device to be attached to differently sized fuse holders. Additionally, to allow line crews to quickly and safely install the fuse-monitoring device, the fuse-monitoring device may also include a hot-stick attachment mechanism such that a lineman can install the fuse-monitoring device on a fuse holder using a hot stick (i.e., an insulated pole often made of fiberglass).

The fuse-monitoring device may also include one or more movement sensors that generate sensor data indicating movement of the fuse-monitoring device. For instance, the movement sensor may be an accelerometer, a gyroscope, a ball bearing tilt switch, and/or any other type of sensor that generates data which can be used to determine if a change in position and/or orientation of the fuse-monitoring device has occurred. The fuse-monitoring device may determine that more than a threshold amount of movement or more than a threshold change in orientation has occurred to ensure

that wind or other causes of slight movement are not identified as a false positive for the opening of the fuse holder of the fuse cutout.

Upon detecting a change in orientation and/or a change in position of the fuse-monitoring device that indicates the fuse holder has swung open, the fuse-monitoring device may transmit, or otherwise send, a notification to one or more other devices that indicate the fuse cutout has disconnected. For instance, the fuse-monitoring device may include a GPS sensor and send a location of the fuse-monitoring device that was determined using the GPS sensor to another device. Thus, the fuse-monitoring device may send a notification to another device, such as an intermediary node in a communication network, or directly to a server of the utility provider that manages the fuse cutout, that indicates the location of the fuse cutout that has opened. In some examples, the fuse-monitoring device may send the location determined using the GPS sensor upon being installed on the fuse holder. In this way, the utility provider is able to manage the locations of their installed fuse-monitoring devices. Thus, when a subsequent notification is received from the fuse-monitoring device indicating that the fuse holder of the fuse cutout has opened, the utility provider may determine the location of the fuse-monitoring device based solely on the device identifier that is included in the notification.

In some instances, the fuse-monitoring device may be battery powered by an internal battery supply. In such examples, it may be advantageous to switch into a lower-power mode at different times. For example, once the fuse-monitoring device has detected a change in orientation and/or position that indicates the fuse holder opened, and sent the notification that the fuse holder opened to the provider company, the fuse-monitoring device may enter into a lower-power mode by powering down some, or all, of the electric components in order to save power. The fuse-monitoring device may include one or more input devices, such as a button, that switch the fuse-monitoring device from the lower-power mode into the normal-power mode upon receiving input. For instance, a lineman that has replaced the fuse holder on the fuse cutout may press the button to cause the fuse-monitoring device to leave the lower-power mode and enter into the normal-power mode to detect the fuse holder swinging open again. In this way, changes in position and/or orientation of the fuse-monitoring device that may occur while the fuse holder is open and swinging around and/or during movement of the fuse-monitoring device may not drain the battery of the fuse-monitoring device.

In various examples, the fuse-monitoring device may include a communication component that allows the fuse-monitoring device to send the notification to the utility provider on its own. In other words, the fuse-monitoring device may include a communication component that allows the fuse-monitoring device to communicate over various networks, such as cellular network and/or Advanced Metering Infrastructure (AMI) networks. However, to save power and/or reduce the cost of manufacturing the fuse-monitoring device, the fuse-monitoring device may include a less complex communication component that allows the fuse-monitoring device using short-range communication standards (e.g. Bluetooth, Wi-Fi, ZigBee, etc.). In such examples, the fuse-monitoring device may transmit or send the notification that the fuse holder has opened to a hub device that is within a transmission range of the short-range communication standards, such as on a same power pole as the fuse cutout. In turn, the hub device may then cause the notification to be sent, or relayed, to the servers of the utility provider.

Once the utility provider has received the notification that the fuse-monitoring device has detected an opening of the fuse holder of a fuse cutout, the utility provider may take an appropriate action. For instance, the notification may indicate a time at which the fuse holder opened, a device identifier for the fuse-monitoring device, and/or a location of the fuse-monitoring device. In some examples, the utility provider may have previously received and stored the location of the fuse-monitoring device, and may only receive the device identifier for the fuse-monitoring device in order to determine the location. Once the utility provider has received the notification that the fuse-monitoring device detected an opening of a fuse holder, the utility provider may dispatch a line crew or lineman to perform the appropriate maintenance to remedy the condition that resulted in the overcurrent, and/or to replace the fuse holder. The line crew may be provided with the GPS location of the fuse-monitoring device, and may also be provided with an indication of the type of fuse that the fuse-monitoring device is monitoring. In this way, the line crew can ensure they have the correct fuse holder to replace the blown fuse link.

In some examples, the fuse-monitoring device may further include various output devices that locally help the line crew identify the blown fuse holder. For instance, the fuse-monitoring device may include one or more lights which light up once the fuse-monitoring device detects that the fuse holder swung open. Additionally, or alternatively, the fuse-monitoring device may include one or more loudspeakers that emit an alarm sound once the fuse-monitoring device detects that the fuse holder swung open. In this way, when the line crew approaches the GPS location of the fuse-monitoring device, the local indications provided by the fuse-monitoring device may further help the line crew quickly determine which fuse-monitoring device is attached to the blown fuse holder.

The techniques described herein effect and improve upon fault detection devices, and/or other electric power grid devices, in various ways. Rather than utilizing more resource hungry, power hungry, and expensive sensors or hardware, the fuse-monitoring devices described herein utilize simple sensors, such as motion sensors, which require less processing power, less battery power, and are inexpensive. Thus, the internal battery for the fuse-monitoring device may experience a longer life, and the processor requirements may be lessened for the fuse-monitoring device, while achieving at least the same results as traditional fault indication devices.

While various techniques described in this application include the use of movement sensors to detect movement of a fuse cutout, any other type of sensor usable to determine that a fuse cutout has blown may be used. For example, a fuse holder may not always swing open when the fuse has blown. However, other types of sensors may be utilized to determine that the fuse has blown despite there not being a swinging motion. Thus, the fuse-monitoring devices described herein may in addition to movement sensors, or as an alternative to movement sensors, include one or more of a vibration sensor (e.g., accelerometer), a thermal sensor, a microphone, an inductive sensor, etc. For instance, an accelerometer may detect the fuse holder vibrating when the fuse has blown, but not swinging, that indicates the fuse has blown. A thermal sensor may detect heat that is emitted from a fuse melting in the fuse holder when the fuse has blown. A microphone may detect sound that is characteristic of a fuse blowing inside of the fuse holder, etc.

While the examples described herein are primarily with respect to monitoring fuse cutouts, some or all of the

techniques are equally applicable to other types of devices, such as reclosers, regulators, etc. For instance, the use of unique identifiers and GPS location data may also be utilized to store and monitor locations of electric power devices in the field.

Certain implementations and embodiments of the disclosure will now be described more fully below with reference to the accompanying figures, in which various aspects are shown. However, the various aspects may be implemented in many different forms and should not be construed as limited to the implementations set forth herein. The disclosure encompasses variations of the embodiments, as described herein. Like numbers refer to like elements throughout.

FIG. **1** illustrates an example environment **100** where fuse-monitoring devices **102**(**1**), **102**(**2**), and **103**(**3**) (collectively referred to as "fuse-monitoring devices **102**") are attached to fuse cutouts **104**(**1**), **104**(**2**), and **104**(**3**) (collectively referred to as "fuse cutouts **104**") for a three-phase power line on a utility pole **106** in an electric power grid. The illustrated fuse-monitoring devices **102** are installed to monitor the fuse cutouts **104** in order to help a utility provider, or other entity, determine a location of a fuse cutout **104** with a blown fuse. Although the fuse-monitoring devices **102** are illustrated as being used for three-phase power lines, any number of fuse-monitoring devices **102** may be utilized for any number of fuse cutouts **104**. The techniques described herein may be applied for a single fuse cutout **104** for single-phase power, two fuse cutouts **104** for two-phase power, three phase cutouts **104** for three-phase power, a plurality of fuse cutouts **104** for an entire service lateral, or any number of fuse cutouts **104**. In such examples, any number of fuse-monitoring devices **102** may be employed to monitor the various numbers of fuse cutouts **104**. For instance, one fuse-monitoring device **102** may be used for each fuse cutout **104** involved, one fuse-monitoring device **102** may be used for three fuse cutouts **104** for three-phase power, or any other ratio of fuse cutouts **104** to fuse-monitoring devices **102**.

Generally, the fuse-monitoring device **102** may comprise a box, or any other structure, configured to be detachably coupled to a fuse holder of a fuse cutout **104**. For instance, the fuse-monitoring device **102** may include, or have, attachment mechanisms that allow for the fuse-monitoring device **102** to be detachably coupled to a fuse holder of a fuse cutout **104**. In some examples, the fuse-monitoring device **102** may be removed by a utility provider, serviced, and re-provisioned in the field for use on another fuse cutout **104**.

As illustrated in the blow-up **108** of the fuse-monitoring device **102** and the fuse cutout **104**, the fuse-monitoring device **102** may include press-fit or snap-fit clips that allow the fuse-monitoring device **102** to be removably attached to a fuse holder of the fuse cutout **104**. However, any other type of attachment mechanism may be utilized to attach the fuse-monitoring device **102** to the fuse holder of the fuse cutout **104**. As illustrated, each of the fuse cutouts **104** are configured to prevent, for a respective phase, an overcurrent from flowing to one or more transformers **110**. However, the techniques are equally applicable for any type of fuse cutouts **104** configured to prevent overcurrent from flowing to devices and/or loads.

FIG. **1** further provides an example electrical grid **112** in which the techniques performed by the fuse-monitoring devices **102** are applicable. As illustrated, the example electrical grid **112** includes power plants **114** that generate electricity to be provided to various loads, such as consumer loads. The power generated by the power plant **114** may flow through one or more step-up transformers **116** which step up a voltage of the power generated by the power plant **114** to a voltage that is used to transmit the power over transmission lines **118** (e.g., step-up the voltage from 12 kilovolts (kV) to 500 kV). The power may be transmitted over the transmission lines at the stepped-up voltage, and then pass through a first step-down transformer **120** that may step down the voltage to a voltage that is used to distribute power across distribution lines **122** (e.g., step-down the voltage from 500 kV to 13 kV). After being distributed across the distribution lines **122**, the power may then be stepped down again using a step-down transformer **124** to a voltage usable by power loads **126** (e.g., step-down the voltage from 13 kV to 240V).

In the illustrated example, the fuse cutouts **104** may be preventing overcurrent from flowing to the transformers **110**, which may be the step-down transformer **124** (e.g., distribution transformer) where the utility pole **106** is part of a distribution line **122**. However, the fuse cutouts **104** may be positioned to protect any type of transformer or electrical device from current surges and overloads.

FIG. **2** illustrates an example environment **200** where at least one fuse-monitoring device **102** determines that a fuse of a fuse cutoff **104** has blown. The fuse-monitoring device **102**, and/or a hub device **202**, may send a notification **204** to a utility provider **206** that indicates the location in the distribution lines **122** of the fuse cutout **104** with the blown fuse.

Generally, the fuse cutout **104** may be a combination of a fuse and a switch such that, when an overcurrent caused by a fault in the transformer passes through the fuse of the fuse cutout **104**, the fuse will melt and cause the switch to open the fuse holder, thereby disconnecting the transformer from the power line. The fuse holder may be mounted at an angle, such as 20 degrees off vertical, so the center of gravity of the fuse holder is displaced such that the fuse holder will rotate, or swing, and fall open under its own weight when the fuse blows. Thus, the fuse holders of fuse cutouts **104** may swing open when the fuse blows.

In some examples, the techniques performed by the fuse-monitoring device **102** may take advantage of the movement of the fuse holder of the fuse cutouts **104** to determine that the fuse blew. For instance, the fuse-monitoring device **102** may include a movement sensor that detects at least one of a change in position or change in orientation of the fuse-monitoring device **102**. Thus, when the fuse-monitoring device **102** is attached to the fuse holder of the fuse cutout **104**, and the fuse melt or blows thereby resulting in the fuse holder swinging open (as illustrated), the fuse-monitoring device **102** is able to detect, using the movement sensor, that the fuse holder opened, and thus determine that the fuse blew.

In some examples, the fuse-monitoring device **102** may include a communication component and logic that enables the fuse-monitoring device **102** to transmit the notification **204** over one or more networks **208** to servers **210** of the utility provider **206**. For instance, the fuse-monitoring device **102** may include a cellular network modem, a communication component configured to communicate over various utility networks (e.g., Advanced Metering Infrastructure (AMI) networks, Automatic Meter Reading (AMR) networks, etc.), and/or various wide-area networks (e.g., Internet). However, the network(s) **208** may comprise any type of network, and/or any combination of wired and/or wireless networks.

In various examples, the fuse-monitoring devices **102** may each be configured to communicate with a hub device **202** over shorter distances, such as by using a short-range

wireless standard (e.g., Bluetooth, Wi-Fi, ZigBee, etc.). For instance, the fuse-monitoring devices **102** may be "dumb" nodes in that they have smaller processors and/or communication components than the hub device **202**, which may elongate the battery life of the fuse-monitoring devices **102**. Further, the hub device **202** may be a "smart" node in that it is capable of communicating, using a communication component **202**, over the various network(s) **208**. The hub device **202** may be located within a transmission range of the short-range wireless standard, such as mounted on the utility power **106**, and be coupled to one or more of the fuse-monitoring devices **102**.

The hub device **202** may further include logic **214** to perform one or more functions. For instance, the hub device **202** may couple to (and create a system with) each of the fuse-monitoring devices **102**, and receive data from each of the fuse-monitoring devices **102**. The hub device **202** may receive device identifiers for each of the fuse-monitoring devices **102**, receive notifications **204** from the fuse-monitoring devices **102** indicating that a movement was detected due to a fuse of a fuse holder blowing, receive time data indicating a time at which the fuse blew, receive location data indicating GPS coordinates for the fuse-monitoring devices **102**, and so forth. Accordingly, if the hub device **202** receives a notification **204** from a fuse-monitoring device **102**, the hub device **202** may determine, using the logic **214**, to relay the notification **204** through the network(s) **208** to the servers **210**. In some examples, the notification **204** may indicate one or more a location **216** indicating a GPS location of the fuse-monitoring devices **102** (and associated fuse cutouts **104**), a device ID **218** indicating a unique device identifier for the fuse-monitoring device(s) **102** that detected the blown fuse, and/or a time **220** at which the fuse-monitoring device **102** detected the movement caused by the blown fuse in the fuse holder of the opened fuse cutout **104**.

The logic **214** of the hub device **202** may further perform additional operations. For instance, if two of the three fuse-monitoring devices **102** send a notification to the hub device **202** that movement was caused by blown fuses, then the logic **202** may determine that it is likely that all three phases are actually out. Further, the logic **214** of the hub device **202** may cause the communication component **212** to periodically (e.g., daily) ping the fuse-monitoring devices **102** to ensure that communications are established, and also notify the servers **210** that the hub device **202** is able to communicate with each of the fuse-monitoring devices **102**.

Upon receiving the notification **204**, the servers **210** may perform various operations. For instance, the servers **210** of the utility provider **206** may determine, based on the device ID **218**, a type of fuse (e.g., **100**A, **200**A, **300**A, etc.) in the fuse cutout **104** that has blown and needs to be replaced. In some examples, the servers **210** may have previously received, and stored, the location **216** of the fuse-monitoring device(s) **102**. In such examples, the notification **204** may simply include the device ID **218** as the servers **210** know, for each device ID, the location **216**. Upon determining that the fuse-monitoring device(s) **102** detected movement indicating a blown fuse for the fuse cutout(s) **104**, the servers **210** may cause a line crew **222** to be dispatched from a physical location **224** of the utility provider to the location **216** on the distribution lines **122**. The line crew **222** may also know the type of fuse that needs to be replaced for the fuse cutout **104** that blew. In this way, rather than tracing the blown fuse of the fuse cutout **104** using customer calls, the utility provider **206** may utilize the notification **204** received from the hub device **202** or the fuse-monitoring device(s) **102** themselves.

FIG. **3**A illustrates an example system **300** including a fuse-monitoring device **102** being detachably coupled to an example fuse cutout **104**. In the illustrated example, the fuse-monitoring device **102** may include one or more attachment mechanisms **302** configured to detachably couple the fuse-monitoring device **102** to the fuse cutout **104**. Further, the fuse-monitoring device **102** may comprise a device housing **304** that houses the components of the fuse-monitoring device **102**, including mechanical components, electrical components, and so forth.

The fuse cutout **104** may generally comprise a combination of a fuse and a switch. The fuse cutout **104** may be positioned on overhead feeder lines and designed to protect distribution transformers from any current spikes or surges that can overload equipment. The fuse cutout **104** may include a fuse holder **306**, also known as the tube or "door," that contains the fuse link. The fuse holder **306** may act as a switch that, when the fuse melts or otherwise operates, the fuse holder **306** will drop open disengaging the switch from the line. This ensures any downstream circuits are electrically isolated. The fuse holder **306** may be held in place by an upper contact **308** and a lower contact **310**. The upper contact may disengage from the fuse holder **306** when the fuse melts, and stay connected to the lower contact **310** to swing open. The fuse cutout **104** may also include the insulator body **312** which may comprise either polymer or porcelain material. Further, the fuse cutout **104** may include a hot-stick ring **314** that allows a lineman to utilize a hot-stick to manually replace or reinstall a fuse holder **306**.

As illustrated, the fuse-monitoring device **102** may be connected to the fuse holder **306** of the fuse cutoff **104** using the attachment mechanisms **302**. Although not illustrated, in some examples the fuse-monitoring device **102** may also include a hot-stick attachment mechanism by which a lineman can interact with using a hot-stick to install the fuse-monitoring device **102** to the fuse holder **306**.

FIG. **3**B illustrates an example fuse-monitoring device **102** attached to an example fuse cutout **104** to detect a swing movement **316** of a fuse holder **306** of the fuse cutout **104**. As illustrated, when a fuse blows within the fuse holder **306**, the fuse holder **306** detach from the upper contact **308** of the fuse cutout **104** and swing open (e.g., swing movement **316**). In this way, the fuse-monitoring device **102** may utilize the movement sensor to detect the movement of the fuse holder **306** which indicates that the fuse blew.

FIG. **4** illustrates component diagram **400** of an example fuse-monitoring device **102** configured to determine that a fuse cutout **104** has blown a fuse, and notify a utility provider **206** of a location of the fuse cutout **104**.

The fuse-monitoring device **102** may include one or more processors **402** configured to power components of the fuse-monitoring device **102**, such as hardware components and software components. The fuse-monitoring device **102** may include one or more power supplies **404** as well, such as an internal battery. The internal battery may, in some examples, be recharged (e.g., recharged by a solar panel). In some examples, the power supply **404** may comprise an external power supply in some examples, such as an electrical connection to the power line in the distribution system.

The fuse-monitoring device **102** may further include one or more movement sensors **406** configured to generate sensor data **408** indicating changes in orientation and/or changes in position. For instance, the movement sensor(s) **406** may comprise at least one of an accelerometer, a

gyroscope, a compass, a magnetometer, a ball bearing tilt switch, and/or any other type of motion and/or inertial sensor.

The fuse-monitoring device **102** may also include one or more attachment mechanisms **410**, such as attachment mechanisms **302**. The attachment mechanism(s) **410** may be used to detachably couple the fuse-monitoring device **102** to a fuse holder **306** of a fuse cutout **104**. In some examples, the attachment mechanism(s) **410** may be interchangeable such that differently sized attachment mechanism(s) **410** may be placed on the fuse-monitoring device **102** in order to couple to differently sized fuse holders **306**. For instance, the fuse holders **306** may vary in diameter (e.g., ½ inch diameter, ¾ inch diameter, etc.), and the attachment mechanism(s) **410** may be configured, or sized, to at least partially wrap around, snap onto, etc., the differently sized diameters. In some examples, the attachment mechanism(s) **410** may be removeable such that differently sized attachment mechanism(s) **410** may be removed and added for a fuse-monitoring device **102** to attach to differently sized fuse holders **306** for different types of fuses. The attachment mechanism(s) **410** may further include a hot-stick attachment mechanism (e.g., a ring) that allows a lineman to utilize a hot-sick to install the fuse-monitoring device **102** to a fuse holder **306**.

The fuse-monitoring device **102** may also include a network interface **412** which comprises a communication component **414**. The network interface(s) **412** may enable communications between the fuse-monitoring device **102** and other networked devices, such as the hub device **202** and/or the servers **210**. Such network interface(s) **412** can include one or more network interface controllers (NICs) or other types of transceiver devices to send and receive communications over a network, such as network(s) **208**. For instance, the network interface(s) **412** may include a personal area network (PAN) component to enable communications over one or more short-range wireless communication channels. For instance, the PAN component may enable communications compliant with at least one of the following standards IEEE 802.15.4 (ZigBee), IEEE 802.15.1 (Bluetooth), IEEE 802.11 (WiFi), or any other PAN communication protocol. Furthermore, the network interface(s) **412** may include a wide area network (WAN) component to enable communication over a wide area network. The networks that the fuse-monitoring device **104** may communicate over may represent an array of wired networks, wireless networks, such as WiFi, or combinations thereof.

The fuse-monitoring device **102** may also include a global positioning system (GPS) sensor **416**, which may comprise receivers with antennas that use a satellite-based navigation system with a network of satellites. The fuse-monitoring device **102** may, at least periodically, obtain GPS coordinates indicating a location, or an absolute geographic location, of the fuse-monitoring device **102**. However, in some examples, the fuse-monitoring device **102** may include a cellular modem configured to triangulate the location of the fuse-monitoring device **102** using cell towers. Thus, the fuse-monitoring device **102** may generate, using the GPS sensors **416**, the location data **418** that indicates the location of the fuse-monitoring device **102**.

The fuse-monitoring device **102** may also include one or more input devices **420** to receive input from a user, such as a lineman. The input device(s) **420** may include one or more buttons, one or more displays, and/or other input device(s) **420** to receive input from a user. Further, the fuse-monitoring device **102** may include one or more output devices **422**, such as a display, a loudspeaker, one or more lights (e.g., light emitting diodes), and/or other types of output device(s) **422**.

The fuse-monitoring device **102** may also include computer-readable media **424**, which may store various components, or computer-executable instructions configured to, when executed by the processor(s) **402**, perform various operations. The computer-readable media **424** may include an operation system **426** that is configured to manage hardware and/or software resource devices such as the network interface(s), the I/O devices of the respective apparatuses, and so forth, and provide various services to applications or components executing on the processors.

The computer-readable media **424** may also store an installation component **428** configured to perform various operations for installing, and after installing, the fuse-monitoring device **102**. The installation component **428** may determine that the fuse-monitoring device **102** has been attached to a fuse holder **306**. For instance, the installation component **428** may detect, such as by using an input device **420** like a button, that the fuse-monitoring device **102** has been connected to fuse holder **306**. The button may be positioned on an inside of an attachment mechanism **410** such that, when the fuse-monitoring device **102** is attached to a fuse holder **306**, the button is pressed. In this way, and other ways in some examples, the installation component **428** may detect that the fuse-monitoring device **102** has been attached to a fuse holder **306**. The installation component **418** may perform various operations once installed on the fuse holder **306**. For example, the installation component **418** may utilize the GPS sensor **416** to generate the location data **418**. Further, the installation component may cause the fuse-monitoring device **102** to transmit or send, using the network interface **412**, the location data **418** and a device identifier **430** for the fuse-monitoring device **102** to the hub device **202**, or the servers **210**. In this way, the utility provider **206** may determine the location of the fuse-monitoring device **102**, as well as the device ID **430**, for the fuse-monitoring device **102**. The device ID **430** may comprise a device serial number, an IP address, and/or another device ID **430** that is unique to the fuse-monitoring device **102**.

The computer-readable media **424** may further store a location component **432** configured to determine the location data **418**. For example, the location component **432** may cause the GPS sensor **416** to collect the location data **418** periodically, continuously, and/or upon the fuse-monitoring device **102** detecting movement. The computer-readable media **424** may store a movement-detection component **434** configured to analyze sensor data **408** generated by the movement sensor(s) **406**. For instance, the movement-detection component **434** may determine that the orientation and/or position of the fuse-monitoring device **102** has changed by more than a threshold amount. In this way, false positives such as the wind moving the utility pole **106**, and/or other false positives, do not result in a detection of a blown fuse when the fuse did not blow.

The fuse-monitoring device **102** may further include a data store **436** that stores sensor data **408**, location data **418**, device identifier **430**, and/or time stamp data **438** that indicates the time at which a blown fuse was detected due to swing movement **316** of the fuse holder **306**.

The fuse-monitoring device **102** may, in addition or as an alternative to the movement sensor(s) **406**, may include one or more sensors **440** to determine that a fuse has blown. A fuse holder may not always swing open when the fuse has blown. However, other types of sensors **440** may be utilized

to determine that the fuse has blown despite there not being a swinging motion. Thus, the fuse-monitoring devices **102** described herein may in addition to movement sensors **406**, or as an alternative to movement sensors **406**, include one or more of a vibration sensor **440** (e.g., accelerometer), a thermal sensor **440**, a microphone (e.g., input device **420**), an inductive sensor **440**, etc. For instance, an accelerometer may detect the fuse holder **306** vibrating when the fuse has blown, but not swinging, that indicates the fuse has blown. A thermal sensor **440** may detect an increase in heat that is emitted due to a fuse melting in the fuse holder **306** when the fuse has blown. A microphone may detect sound that is characteristic of a fuse blowing inside of the fuse holder **306**, etc. Each of the sensors **440** may generate sensor data **408** which may be analyzed by a component of the fuse-monitoring device **102** (e.g., movement-detection component **434**) in order to determine that a fuse has blown. For instance, a threshold amount of heat, or a threshold change in heat emitted, may indicate that a fuse has blown. A threshold amount of vibration, or vibration detected for a particular period of time indicative of a fuse blowing, may indicate that a fuse has blown. Further, a sound with a particular acoustic signature, or length of time, may indicate that a fuse has blown.

In some examples, the fuse-monitoring devices **102** may include two or more sensors that are used in conjunction to detect that the fuse of the fuse cutout **104** has blown. For instance, the fuse-monitoring devices **102** may include two or more of a movement sensor **406**, a thermal sensor **440**, a microphone (e.g., input device **420**), and/or a vibration sensor **440**. The two or more sensors could each generate respective sensor data that could be used to determine, with a higher level of confidence, whether or not the fuse has blown in the fuse cutout **104**. For instance, the movement sensor **406** indicates movement, and a thermal sensor also indicates heat, the fuse-monitoring device **102** may determine that the fuse has blown. In some examples, the fuse-monitoring device **102** may assign confidence scores to sensor data generated by the two or more sensors to determine whether or not the fuse has blown. For instance, a movement sensor **406** may generate sensor data **408** indicating that movement was detected, but the movement may not be greater than a threshold amount of movement to have high enough confidence that the fuse blown. In such an example, the thermal sensor **440** may also generate sensor data **408** that indicates heat was emitted from the fuse cutout **104**. The combination of the thermal heat, in addition to the movement, may give the fuse-monitoring device enough confidence that the fuse did blow for the fuse cutout **104**. Additionally, different combinations of sensors may be utilized, and any number of sensors may be included in, the fuse-monitoring device **102**. In some examples, two or more of the sensors may individually generate sensor data indicating that a fuse has blown in order for the fuse-monitoring device **102** to be confident that the fuse has blown. In some examples, none of the two or more sensors may indicate that the fuse has blown on its own, but the combination of their respective sensor data may give the fuse-monitoring device **102** enough confidence to determine that the fuse has blown.

As used herein, a processor, such as processor(s) **402** may include multiple processors and/or a processor having multiple cores. Further, the processors may comprise one or more cores of different types. For example, the processors may include application processor units, graphic processing units, and so forth. In one implementation, the processor may comprise a microcontroller and/or a microprocessor. The processor(s) **402** may include a graphics processing unit (GPU), a microprocessor, a digital signal processor or other processing units or components known in the art. Alternatively, or in addition, the functionally described herein can be performed, at least in part, by one or more hardware logic components. For example, and without limitation, illustrative types of hardware logic components that can be used include field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), application-specific standard products (ASSPs), system-on-a-chip systems (SOCs), complex programmable logic devices (CPLDs), etc. Additionally, each of the processor(s) **402** may possess its own local memory, which also may store program components, program data, and/or one or more operating systems.

Further, functional components may be stored in the respective memories, or the same functionality may alternatively be implemented in hardware, firmware, application specific integrated circuits, field programmable gate arrays, or as a system on a chip (SoC). In addition, while not illustrated, each respective memory, such as computer-readable media **424** and/or memory, discussed herein may include at least one operating system (OS) component that is configured to manage hardware resource devices such as the network interface(s), the I/O devices of the respective apparatuses, and so forth, and provide various services to applications or components executing on the processors. Such OS component may implement a variant of the FreeBSD operating system as promulgated by the FreeBSD Project; other UNIX or UNIX-like variants; a variation of the Linux operating system as promulgated by Linus Torvalds; the FireOS operating system from Amazon.com Inc. of Seattle, Wash., USA; the Windows operating system from Microsoft Corporation of Redmond, Wash., USA; LynxOS as promulgated by Lynx Software Technologies, Inc. of San Jose, Calif.; Operating System Embedded (Enea OSE) as promulgated by ENEA AB of Sweden; and so forth.

FIGS. **5** and **6** are flow diagrams illustrating example processes **500** and **600** according to the techniques described herein. The flow of operations in the example processes are illustrated as a collection of blocks and/or arrows representing a sequence of operations that can be implemented in hardware, software, firmware, or a combination thereof. The order in which the blocks are described is not intended to be construed as a limitation, and any number of the described operations can be combined in any order to implement one or more methods, or alternate methods. Additionally, individual operations may be omitted from the flow of operations without departing from the spirit and scope of the subject matter described herein. In the context of software, the blocks represent computer instructions that, when executed by one or more processors, perform the recited operations. In the context of hardware, the blocks may represent one or more circuits (e.g., application specific integrated circuits—ASICs) configured to execute the recited operations.

FIG. **5** illustrates a flow diagram of an example process **500** for detecting movement of a fuse-monitoring device **102** that indicates that a fuse of a fuse cutout **104** has blown.

At **502**, the fuse-monitoring device **102** may determine, at least partly using a GPs sensor, a location of the fuse-monitoring device. For example, the installation component **428** may, upon installing the fuse-monitoring device **102** onto a fuse holder **306**, cause the GPS sensor **416** to determine location data **418** indicating a location of the fuse-monitoring device **102**. In some examples, the movement-detection component **434** may cause the GPS sensor **416** to determine the location data **418** upon detecting more than a threshold change in orientation and/or position.

At **504**, the fuse-monitoring device **102** may detect, at least partly using the movement sensor, at least one of a change in the orientation of the fuse-monitoring device **102** or a change in the position of the fuse-monitoring device **102**. In some examples, at **504**A the movement sensor(s) **406** may generate sensor data **408** that represents the change in orientation and/or the change in movement. The movement-detection component **434** may, at **504**B, analyze the sensor data to detect more than a threshold change in the at least one of the orientation or the change in the position.

At **506**, the fuse-monitoring device **102** may send, at least partly using the communication component, a notification indicating the at least one of the change in the orientation or the change in the position of the fuse-monitoring device **102**. In some examples, the notification may include one or more of location data indicating a GPS location of the fuse-monitoring device **102**, device identifier data indicating a device ID of the fuse-monitoring device **102**, and/or time-stamp data indicating a time at which the change in the orientation and/or the change in the position of the fuse-monitoring device **102** occurred.

In some instances, sending the notification may comprise causing the notification to be sent to a server associated with a central office over an advanced metering infrastructure (AMI) network, or causing the notification to be sent to the server associated with the central office over a cellular network. In various examples, sending the notification may comprise transmitting, over a short-range wireless communication standard, the notification to a smart node (e.g., hub device) in an advanced metering infrastructure (AMI) network.

In some examples, the fuse-monitoring device **102** may, optionally at **508**, enter into a lower-power mode. For instance, the fuse-monitoring device **102** may power down at least one component, such as the movement sensor, the communication component, etc., after sending the notification. In this way, the fuse-monitoring device **102** may refrain from consuming battery power until the fuse-monitoring device **102** has been reinstalled with a new fuse, and/or installed in a new location after being taken down from a previous location.

In some examples, based at least in part on detecting at least one of the change in the orientation or the change in the position of the fuse-monitoring device **102**, the fuse-monitoring device may perform at least one of causing a loud speaker included in the fuse-monitoring device **102** to output sound, or cause a light of the fuse-monitoring device **102** to output light.

In various examples, a system includes multiple fuse-monitoring devices **102** monitoring different phases of a power line, as well as a hub device **202** configured to communicate with the multiple fuse-monitoring devices **102**. Each of the fuse-monitoring devices **102** may monitor fuse holders **306** of respective fuse cutouts **104** on each phase.

FIG. **6** illustrates a flow diagram of an example process **600** for using sensor data **408** generated by one or more sensors **406** and/or **440** of a fuse-monitoring device **102** to determine that a fuse of a fuse cutout has blown.

In some examples, the fuse-monitoring device **102** may be installed, such as being removeably or detachably coupled, to a fuse holder **306** of a fuse cutout **104**. For example, a line crew **222** may use a hot stick, or otherwise install, the fuse-monitoring device **102** on the fuse holder **306**. In some examples, the fuse-monitoring device **102** may include a GPS sensor **416** that may be utilized to determine the geographic location of the fuse-monitoring device **102**. However, more simply fuse-monitoring devices **102** may not include GPS sensors, or any other location sensors. Instead, the line crew **222** may record or otherwise determine a location of the fuse-monitoring device **102** upon installation, and keep track of the location of the fuse-monitoring device **102** at a location of the utility provider **206**. In this way, the utility provider **206** may know the location of the fuse-monitoring device **102**, but the fuse-monitoring device **102** may not include a location sensor to notify the utility provider **206** of the location of the fuse-monitoring device **102**.

At **602**, the fuse-monitoring device **102** may generate, using one or more sensors, sensor data associated with the fuse tube of the fuse cutout. Generally, the sensors used to generate the sensor data **408** may include a movement sensor **406**, a sensor **440**, and/or any combination of multiple sensors **406** and/or **440**. For instance, the one or more sensors may include a movement sensor **406** configured to generate sensor data that may be used to indicate at least one of a change in the orientation of the fuse-monitoring device **102** or a change in the position of the fuse-monitoring device **102**. In some examples, the movement sensor(s) **406** may generate sensor data **408** that represents the change in orientation and/or the change in movement. The movement-detection component **434** may analyze the sensor data **408** to detect more than a threshold change in the at least one of the orientation or the change in the position.

In various examples, the fuse-monitoring device **102** may include additional, or alternative, sensors **440** to generate sensor data **408**. For instance, the sensor may comprise a thermal sensor **440** configured to generate the sensor data representing thermal heat emitted. The fuse-monitoring device **102** may also include a microphone to detect sound that indicates the fuse blew, such as a sound that is at a threshold volume, has a known acoustic signature, or lasts for a known period of time.

At **604**, the fuse-monitoring device **104** may determine, based at least in part on the sensor data, an event indicative of a fuse in the fuse tube blowing. In some examples, the sensor comprises a thermal sensor configured to generate the sensor data representing thermal heat emitted, and determining the event indicative of the fuse blowing includes analyzing the sensor data to detect at least one of more than a threshold change in the thermal heat emitted from the fuse tube or more than a threshold amount of the thermal heat emitted from the fuse tube.

In some examples, the sensor comprises a movement sensor configured to detect at least one of a change in orientation of the fuse-monitoring device or a change in position of the fuse-monitoring device, and determining the event indicative of the fuse blowing includes detecting, at least partly using the sensor data, at least one of a change in the orientation of the fuse-monitoring device or a change in the position of the fuse-monitoring device.

At **606**, the fuse-monitoring device **102** may send, at least partly using a communication component and to a device (e.g., hub device **202**, severs **210**, etc.), a notification indicating the even indicative of the fuse blowing. In some examples, the notification may further include one or more of location data indicating a GPS location of the fuse-monitoring device **102**, device identifier data indicating a device ID of the fuse-monitoring device **102**, and/or time-stamp data indicating a time at which the event occurred.

FIG. **7** illustrates a state diagram **700** indicating example power states that a fuse-monitoring device **102** progresses through.

As illustrated, the fuse-monitoring device **102** may originally be in a storage—low power state **702**. For instance, when the fuse-monitoring device **102** is not in use, such as being in storage at a physical location **224** of the utility provider **206**, the fuse-monitoring device **102** may be in the storage—low power state **702** in which the fuse-monitoring device **102** is entirely powered off, or consuming very little power by activating few components.

At "1," the fuse-monitoring device **102** may have power enabled by receiving input via an input device **420**. For example, a line crew **222** may take the fuse-monitoring device **102** to a location on a line, such as a distribution line **122**, at which the fuse-monitoring device **102** will be installed. The line crew **222** may provide input to the fuse-monitoring device **102** via an input device **420**, such as a magnetic switch, a pull tab, or any other electrical, mechanical, and/or electromechanical input device **420**.

The fuse-monitoring device **102** may transition into a register—full power state **704** after receiving the input via the input device **420**. Generally, in the register—full power state **704**, the fuse-monitoring device **102** may be in a normal operation mode where some, or all, of the components are powered by the power supply **404**. For instance, the fuse-monitoring device **102** may initiate the operating system **426**, the installation component **428**, location component **432**, movement-detection component **434**, GPS sensor **416**, sensors **406**/**440**, and or any other devices of the fuse-monitoring device **102**.

At "2," the fuse-monitoring device **102** may enter into monitoring after registration has completed. For instance, the fuse-monitoring device **102** may register by utilizing the GPS sensor **416** to determine location data **418** that is provided to at least one of the hub device **202**, the servers **210**, and/or the line crew **222**. Further, the fuse-monitoring device **102** may instantiate communication connections with the hub device **202**, such as by pairing with the hub device **202** or otherwise registering for communication.

The fuse-monitoring device **102** may enter into a monitor—low power state **706**. In the monitor—low power state **706**, the fuse-monitoring device **102** may power down at least some of the components, such as the GPs sensor **416**, the installation component **428**, the location component **432**, etc. However, the fuse-monitoring device **102** may maintain power to at least some of the components, such as movement sensor **406**, sensors **440**, movement-detection component **434**, and/or other components. In this way, the fuse-monitoring device **102** may provide at least enough power to components that are required to detect a blown fuse, but refrain from powering components that do not help detect a blow fuse.

At "3," the fuse-monitoring device **102** may optionally (not always required) perform a check-in with the hub device **202**. For instance, the fuse-monitoring device **102** may be configured to, at least periodically, transition into a health check—full power **708** state and power at least the network interface **412** to notify the hub device **202** (and/or servers **210**) that the fuse-monitoring device **102** is operating normally. In this way, the hub device **202** and/or servers **210** know that the fuse-monitoring device **102** is operating normally and is healthy, and that any "silence" from the fuse-monitoring device **102** means that the monitored fuse has not blown.

At "4," the fuse-monitoring device **102** may detect a fuse blow according to the various techniques described herein (e.g., swinging of fuse, thermal heat emitted from blown fuse, vibrations corresponding to a blown fuse, sound corresponding to an acoustic fingerprint of a fuse blowing, etc.). The fuse-monitoring device **102** may then transition into a report—full power **710** state. In the report—full power state **710**, the fuse-monitoring device **102** may power various components to report the blown fuse to one or more devices. For instance, the fuse-monitoring device **102** may power the network interface **412** to transmit a notification that the fuse blew to the hub device **202**, servers **210**, etc. Further, the fuse-monitoring device **102** may power the GPS sensor **416** to determine location data **418** to be sent with the notification. In this way, additional power is drawn by components of the fuse-monitoring device **102** in the report—full power state **710** than in the monitor—lower power state **706** from which the fuse-monitoring device **102** transitioned. After reporting the notification of the blown fuse, the fuse-monitoring device **102** may transition back into the monitor—low power state **706**.

At "5," the fuse-monitoring device **102** may receive input via an input device **410** indicating that power is to be disabled. For instance, the fuse-monitoring device **102** may receive input from the line crew **222** via an input device **420**, such as a magnetic switch, a pull tab, or any other electrical, mechanical, and/or electromechanical input device **420**. This may indicate that the fuse-monitoring device **102** is being uninstalled, and the fuse-monitoring device **102** may enter into the storage—low power s**702** state by powering down some or all of the components.

While the foregoing invention is described with respect to the specific examples, it is to be understood that the scope of the invention is not limited to these specific examples. Since other modifications and changes varied to fit particular operating requirements and environments will be apparent to those skilled in the art, the invention is not considered limited to the example chosen for purposes of disclosure, and covers all changes and modifications which do not constitute departures from the true spirit and scope of this invention.

Although the application describes embodiments having specific structural features and/or methodological acts, it is to be understood that the claims are not necessarily limited to the specific features or acts described. Rather, the specific features and acts are merely illustrative some embodiments that fall within the scope of the claims of the application.

What is claimed is:

1. A system comprising:

a fuse-monitoring device comprising:

one or more processors;

an attachment mechanism configured to detachably couple the fuse-monitoring device to a fuse tube of a fuse cutout;

a sensor configured to generate sensor data associated with the fuse tube of the fuse cutout;

a communication component; and

one or more computer-readable media storing computer-executable instructions that, when executed by the one or more processors, cause the one or more processors to:

send, at least partly using the communication component and to a device:

location data associated with a location of the fuse-monitoring device, and

an identifier of the fuse-monitoring device;

generate, at least partly using the sensor, the sensor data;

determine, based at least in part on the sensor data, an event indicative of a fuse in the fuse tube blowing; and

send, at least partly using the communication component and to the device, a notification indicating:

the event indicative of the fuse blowing, and

the identifier of the fuse-monitoring device, the identifier being used to determine the location of the fuse-monitoring device.

2. The system of claim **1**, wherein:

the sensor comprises a thermal sensor configured to generate the sensor data representing thermal heat emitted; and

determining the event indicative of the fuse blowing includes analyzing the sensor data to detect at least one of more than a threshold change in the thermal heat emitted from the fuse tube or more than a threshold amount of the thermal heat emitted from the fuse tube.

3. The system of claim **1**, wherein the fuse-monitoring device comprises a first fuse-monitoring device, further comprising:

a hub device comprising:

one or more second processors;

a second communication component; and

one or more second computer-readable media storing second computer-executable instructions that, when executed by the one or more second processors, cause the one or more second processors to:

receive, from the first fuse-monitoring device, the notification;

receive, from a second fuse-monitoring device, a second notification indicating another event indicative of another fuse in another fuse tube blowing;

determine, based at least in part on the notification and the second notification, that a three-phase power line experienced an overcurrent event; and

sending, at least partly using the second communication component, a third notification indicating the overcurrent event to the device associated with a utility office.

4. The system of claim **1**, wherein:

the sensor comprises a movement sensor configured to detect at least one of a change in orientation of the fuse-monitoring device or a change in position of the fuse-monitoring device; and

determining the event indicative of the fuse blowing includes detecting, at least partly using the sensor data, at least one of a change in the orientation of the fuse-monitoring device or a change in the position of the fuse-monitoring device.

5. The system of claim **1**, wherein the fuse-monitoring device comprises further computer-executable instructions that, when executed, cause the one or more processors to:

cause a loudspeaker included in the fuse-monitoring device to output sound; or

cause a light of the fuse-monitoring device to illuminate.

6. The system of claim **1**, wherein the fuse-monitoring device further comprises another attachment mechanism configured to detachably couple the fuse-monitoring device with a hot stick.

7. The system of claim **1**, wherein the notification further includes time data indicating a time associated with the event indicative of the fuse in the fuse tube blowing.

8. The system of claim **1**, wherein:

the location data and the identifier are sent at a first instance in time; and

the notification is sent at a second instance in time that is after the first instance in time.

9. A method performed at least partly using a fuse-monitoring device, the method comprising:

generating, at least partly using a sensor of the fuse-monitoring device, sensor data associated with a fuse tube of a fuse cutout, wherein the fuse-monitoring device is attached to the fuse tube;

determining, at least partly using the sensor data, an event indicative of a fuse in the fuse tube blowing;

sending, at least partly using a communication component of the fuse-monitoring device, a notification indicating the event indicative of the fuse blowing; and

causing, at least partly responsive to sending the notification, the fuse-monitoring device to transition from a first power mode into a second power mode, wherein the fuse-monitoring device consumes less power in the second power mode than the first power mode.

10. The method of claim **9**, wherein:

the sensor comprises a movement sensor configured to generate the sensor data indicative of at least one of a change in orientation of the fuse-monitoring device or a change in position of the fuse-monitoring device; and

determining the event comprises analyzing the sensor data to identify the at least one of the change in the orientation or the change in the position, wherein the change in the orientation or the change in the position of the fuse-monitoring device indicates that the fuse tube of the fuse cutout has opened.

11. The method of claim **9**, wherein the notification further includes time data indicating a time associated with the event indicative of the fuse blowing.

12. The method of claim **9**, further comprising at least one of, subsequent to determining the event:

outputting, at least partly using a loudspeaker of the fuse-monitoring device, an alert sound; or

outputting, at least partly using a light of the fuse-monitoring device, an alert light.

13. The method of claim **9**, further comprising:

determining, at least partly using a global positioning system (GPS) sensor of the fuse-monitoring device, a location of the fuse-monitoring device,

wherein the notification further includes location data indicating the location of the fuse-monitoring device.

14. The method of claim **9**, wherein the sensor comprises at least one of a movement sensor, a thermal sensor, or a microphone configured to generate the sensor data used to determine the event indicative of the fuse in the fuse tube blowing.

15. The method of claim **14**, wherein the sensor comprises a first sensor, further comprising generating, at least partly using a second sensor of the movement sensor, the thermal sensor, or the microphone, to generate additional sensor data,

wherein:

the second sensor is different than the first sensor; and

the determining the event indicative of the fuse in the fuse tube blowing is based at least in part on the sensor data and the additional sensor data.

16. A system comprising:

one or more processors; and

one or more non-transitory computer-readable media storing computer-executable instructions that, when executed by the one or more processors, cause the one or more processors to perform acts comprising:

receiving, from a sensor, sensor data associated with a fuse tube of a fuse cutout;

determining, based at least in part on the sensor data, a failure of a fuse in the fuse tube;

causing, based at least in part on the failure of the fuse, the system to transition from a first power mode into a second power mode, wherein the system consumes more power in the second power mode than the first power mode; and

sending a notification associated with the failure of the fuse.

17. The system of claim **16**, the acts further comprising at least one of:

causing, based at least in part on the failure of the fuse, a loudspeaker to output sound; or

causing, based at least in part on the failure of the fuse, a light to illuminate.

18. The system of claim **16**, wherein the notification includes a time associated with the failure of the fuse.

19. The system of claim **16**, further comprising a fuse-monitoring device, wherein the sensor comprises a movement sensor configured to generate sensor data representing at least one of a change in orientation of the fuse-monitoring device or a change in position of the fuse-monitoring device.

20. The system of claim **16**, wherein the sensor comprises a thermal sensor configured to generate the sensor data representing thermal heat emitted from the fuse tube.

21. The system of claim **16**, further comprising a microphone, the acts further comprising receiving, from the microphone, audio data associated with the fuse tube, wherein determining the failure of the fuse is further based at least in part on the audio data.

22. The system of claim **16**, further comprising a global positioning system (GPS) sensor, the acts further comprising determining, at least partly using the GPS sensor, a location associated with the fuse tube, wherein the notification further includes the location of the fuse tube.

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